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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Daniel N. Miller *et al.*
Serial No.:	09/621,795
Filing Date:	July 21, 2000
Examiner:	Tae Jun Kim
Group Art Unit:	3746
Title:	METHOD AND APPARATUS OF ASYMMETRIC INJECTION INTO SUBSONIC FLOW OF A HIGH ASPECT RATIO/COMPLEX GEOMETRY NOZZLE

Box Appeal
Assistant Commissioner for Patents
Washington, D.C. 20231

Certification Under 37 C.F.R. 1.8

Date of Mailing: November 29, 2002

I hereby certify that I have caused the documents indicated below to be deposited with the United States Postal Service to Addressee under 37 CFR § 1.8 on the date indicated above and addressed to the Commissioner for Patents, Washington, D.C. 20231 and mailed on the above Date of Mailing.

Robert A. McLauchlan

APPELLANTS' BRIEF UNDER 37 C.F.R. § 1.192

Dear Sir:

This is an appeal from the Office Action mailed May 31, 2002 finally rejecting the 37 claims in the case. Because this Brief is filed within two months of Applicant's Notice of Appeal, Applicants submit that no further fees are due. Please charge the fee under 37 C.F.R. § 1.17(c) for filing this brief and any additional fees, or credit any overpayments, to Deposit Account No. 50-1343 of Hughes & Luce, LLP.

Appellants hereby submit their Brief as follows:

(1) Real Party In Interest

Lockheed Martin Corporation, the assignee of the above-identified application, is the real party in interest.

(2) Related Appeals and Interferences

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There are no other appeals or interferences known to appellant, the undersigned legal representative, or assignee that will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

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(3) Status of Claims

Claims 31-69 stand rejected in the Office Action mailed May 31, 2002.

Claims 51-54, 56, 57, 66-69, 63-69 69stand rejected as being unpatentable under 35 USC 103(a) over McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS.

Claims 51-69 69stand rejected as being unpatentable under 35 USC 103(a) over McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS, as applied above, and further in view of either Kranz et al. (4,351,479) or Warren (3,204,405).

Claims 51-54, 56, 57, 69-65, and 63-39 69stand rejected as being unpatentable under 35 USC 103(a) over the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642).

Claims 51-69stand rejected as being unpatentable under 35 USC 103(a) over the AIAA paper of Miller et al. (IAA 95-2603) of the IDS in view of McCullough (3,698,642), as applied above and further in view of either Kranz et al. (4,351,479) or Warrant (3,204,405).

Claims 31-35, 37-39, 40-42, 44-46, and 48 69stand rejected as being unpatentable under 35 USC 103(a) over Miller et al. and McCullough, and further in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) or AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642), as applied above, and further in view of either Terrier (5,665,415) or Justice (6,000,635)? Claims, 1, 5, 6, 8, 9, 12, 13, 16-18, 20, 23, 24, 30-32 and 37 are rejected under 35 U.S.C. 102(b) as anticipated by 35 U.S.C. 102(b) by Campbell, et al. (US Patent No. 5,617,020).

(4) Status of Amendments

An Amendment is being filed along with this Appeal Brief, in accordance with 37 CFR 1.116(b), to cancel claims, to comply with requirements of form set forth in the Final Office Action, and to present rejected claims in better form for consideration on appeal.

In the Amendment, Claims 34, 39, 43, 45, 50, 58, 64 and 69-74 are cancelled; Claims 31, 44, 51, and 63 are amended to address the Examiner's rejection under 35 U.S.C. 112; and

Claims 31-33, 35-36, 40-42, 44, 46-49, 51-57, 59-63 and 65-68 are amended to more particularly point out and distinctly claim the invention.

(5) Summary of the Invention

The present invention provides a system and method for vectoring a primary flow by varying an effective throat or sonic plane within a ducted primary flow. The present invention controls a primary flow through a nozzle to allow throttling of an engine or vectoring of an engine's thrust.

Using reference numbers from Figures 10 of the application, this system includes an opening **212** for accepting the primary flow **214**. At least one primary injector **276** is located such that injector 276 is inclined to oppose primary flow 214 up-stream of an effective throat or sonic plane 282. At least one supplemental injector 280 is located downstream of primary injector 276. Supplemental injector 280 is inclined to oppose primary flow 214. Additionally, primary injectors 276 and supplemental injectors 280 provide a flow field opposed to a subsonic portion of the primary flow in order to vector primary flow 214. Controllers direct primary injectors 276 and supplemental injectors 280 to provide a flow operable to vary the effective throat or sonic plane. (Page 29, Lines 1-3).

The present invention also provides a method for vectoring a primary flow of fluid in a 3-D nozzle as shown in FIGUREs 1A-1D. Here, fluid from a plurality of primary injectors **24** of FIGURE 2A form slots **12** and **14** of FIGUREs 1A-1C and oppose primary flow **34** of FIGURE 3A, Injectors **24** are approximately parallel to an intended vectoring plane **XY**, **XZ**, or **YZ** as shown in FIGURE 1D. Slot 12 and its injectors are located proximate to the nozzles throat as shown in FIGUREs 5B, 5C and 5D. (page 22, lines 15 – Page 23, Line 2) Fluid is injected a plurality of supplemental injectors in slots **14** that oppose the primary flow 34. These supplemental injectors are located downstream of the throat, and the fluid injected by the combination of primary and supplemental injectors varies or skews an effective throat or sonic plane of said 3-D nozzle of FIGUREs 5A-5E. The injectors expel injection fluid in a direction inclined to oppose the primary flow of the fluid, but approximately an intended vectoring plane **XY**, **XZ**, or **YZ** as shown in FIGURE 1D.

The system and method of the present invention may also include related control systems that vector the primay thrust in a desired direction. . (Page 29, Lines 1-3). As further noted the present invention may use pulsed injection to further achieve these goals.

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As noted in the specification at page 11, lines 3-15, "[p]ulsed injection, when used instead of or in combination with a variable geometry nozzle, can reduce the weight, cost, and complexity of a nozzle. A pulsed injection system reduces the weight of a nozzle by eliminating or limiting the need for durable heavy moving parts such as hinges, seals, actuators, hydraulics and other mechanical items necessary to open and close the typical iris type variable geometry nozzle." This ability allows the present invention to provide "an aircraft equipped with an engine and fixed-geometry nozzle using pulsed injection [with] non-circular exhaust aperture shapes typical of advanced fighter concepts. These aperture shapes, such as elliptical or diamond shapes, allow for better blending and integration into the aircraft aft body structure than typical iris-type nozzles." (See specification at page 11, line 16-23).

(6) Issues Presented For Review

Are Claims 51-54, 56, 57, 66-69, 63-69 unpatentable under 35 USC 103(a) over McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS?

Are Claims 51-69 unpatentable under 35 USC 103(a) over McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS, as applied above, and further in view of either Kranz et al. (4,351,479) or Warren (3,204,405)?

Are Claims 51-54, 56, 57, 69-65, and 63-39, unpatentable under 35 USC 103(a) over the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642)?

Are Claims 51-69 unpatentable under 35 USC 103(a) over the AIAA paper of Miller et al. (IAA 95-2603) of the IDS in view of McCullough (3,698,642), as applied above and further in view of either Kranz et al. (4,351,479) or Warrant (3,204,405)?

Are Claims 31-35, 37-39, 40-42, 44-46, and 48 unpatentable under 35 USC 103(a) over Miller et al. and McCullough, and further in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) or AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642), as applied above, and further in view of either Terrier (5,665,415) or Justice (6,000,635)?

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REMARKS

Objections to the Drawings

The Examiner stated that the sheets of drawings filed on April 8, 2002 have been received but not approved because the Applicants have not submitted a proposed drawing correction in the form of a pen-and-ink sketch showing the changes in red.

The Applicants respectfully submit herewith pen-and-ink changes to the drawings in red as required under MPEP §608.2(v).

The Applicants respectfully submit that flow arrows for the injected fluid have been added to Figures 2B, 3B, 3C, 3D, and 3E. The Applicants respectfully submit that the pitch vector has been modified in Figure 5B to more clearly show that this vector has a vertical component directing the vector into the page.

The Applicants respectfully submit that the angle for 286 of 15° is relative to the longitudinal axis of the engine.

The Applicants respectfully submit that these changes to the drawings address the Examiner's objections and request that these objections be withdrawn and the drawings entered.

Claim Rejections Under 35 USC § 112

The Applicants respectfully submit that independent Claims 31, 44, 51, and 63 have been amended to overcome the Examiner's rejections for the use of negative limitations.

Therefore, the Applicants request that the Examiner withdraw the objections to amended claims under 35 USC § 112.

(7) Grouping of Claims

The claims are grouped as follows:

Group I - 31-33, and 35-36

Group II - 44, and 46-49

Group III - 51-57, 59-63 and 65-68

Each of these groups stands or falls independently.

Explanation of Applicants' Grouping of Claims

The Examiner has rejected 31-33, and 35-36 under 35 U.S.C. 103(b) as anticipated by McCullough in view of Ernst or Miller at al. further in view of Kranz or Warren. Applicants will present a traversal of the Examiner's rejection that applies to all these claims, and Applicants agree that the claims from that rejection in Group I stand or fall together. However, the claims of Group II introduce the limitation that the nozzle is a three dimensional nozzle but does not explicitly state that a controller is used to vector the primary flow. This is a limitation not found in McCullough in view of Ernst or Miller at al. further in view of Kranz or Warren, therefore Applicants' traversal of the Examiner's rejection of these claims will include additional arguments causing the claims in Group II to stand separately from the claims of Group I. Similarly, the claims of Group III introduce the limitations of more than one intended vectoring plane and a controller. Thus this implies a controller as found in Group 1 and a three dimensional nozzle as found in Group II. Therefore Applicants' additional arguments will cause the claims in Group III, too, to stand separately from the claims of Group I.

(8) Argument

Applicants submit that of Claims 31-33, 35-42, 44, 46-49, 51-57, 59-63, and 65-68 are patentable over McCullough, Miller et al., alone or in combination with Ernst, Kranz et al., Terrier (5,665,415) or Justice (6,000,635).

REJECTIONS UNDER 35 USC § 112

The Applicants respectfully submit that independent Claims 31, 44, 51, and 63 have been amended to overcome the Examiner's rejections for the use of negative limitations.

With respect to the examiners statement that "each of the injectors is not adapted to expel the fluid in a direction that is approximately parallel to an intended vector plane," The

applicant respectfully submits that there are three intended vectoring planes that relate to yaw, pitch and roll. These planes are depicted in FIGURE 1D as XY, XZ, and YZ. As shown in FIGURE 5A, the slots, which may not be aligned in a specific direction comprise a number of injector that are themselves aligned to expel fluid within one of the three intended vector plans.

The examiner states that the top and bottom injectors are not both parallel to the same intended vector plane. However, the applicants submits that these injectors provide fluid expelled in the pitch plane **YZ**. This fluid is injected parallel to this plane but in opposing directions.

With respect to the examiners comment that Claims 38 and 57 are not enabled because symmetric flow to vector the primary flow is not taught. As noted in the specifcation on Page 43 at lines 24-30, "a plurality of injectors provide a symmetrical secondary flow around the periphery of throat 270, [decreasing] the effective cross sectional area of throat 270 … and causing an increase in pressure within exhaust chamber 262 and an increase in the velocity of flow 214 as it accelerates through throat 270." Thus, flow has been vectored by increasing its velocity.

With respect to the examiners statement that the claims omitted essential elements, the applicant submits that the pending claims have been amended to overcome these omissions.

REJECTIONS UNDER 35 USC § 103 OVER MCCULLOUGH IN VIEW OF EITHER ERNST OR MILLER ET AL.

Claims 51-54, 56, 57, 66-69, 63-69, stand rejected under 35 USC 103(a) as being unpatentable over McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS.

The Examiner states that "McCullough teaches a nozzle having a primary flow, a primary injector 16, and a secondary injector 18, and valve controllers 22 to direct a flow to vary the effective throat area of the nozzle and perform thrust vectoring (top of col. 2). McCullough further teaches the use of fuel (col. 2, lines 26-28). Alternately, for the controllers, it is clear that the valves require a controller to actuate them. It would have been obvious to one of ordinary skill in the art to employ a software based controller in addition to

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the valves, in order to provide the necessary control over the thrust vectoring and/or throat control. McCullough do not teach the primary and secondary injectors are inclined to oppose the flow."

The Examiner further states "Ernst teaches that it is old and well known in the thrust vectoring art to employ primary and secondary injectors 1, 3 that are either angled perpendicular to the primary flow (Fig. 1) or included to oppose the flow (Fig. 3) and shows that the effective vector O can be increased by using opposed flow (compared Fig. 3 to Fig. 1)."

With respect to Miller et al., the Examiner states "Miller et al. teach a fixed geometry exhaust nozzle used for gas turbine/turbofan engines (which inherently employ compressors) where the nozzle area is varied by a cross flow injected in the upstream direction (Figs. 2-5) in order to achieve a variable throat area. At the throat, the primary flow reaches the sonic condition. Miller shows on the cover sheet of the paper that the flows from the primary and secondary injectors can be angled to oppose the flow. Miller et al. further teach very low injection angles are possible (see top left of fig. 9) and hence, as the angles are very low, the angles will also be approximately parallel the vector angle, which would also be low."

The Examiner concludes: "It would have been obvious to one of ordinary skill in the art to incline the injectors of McCullough to oppose the flow, as taught by either Ernst or Miller et al., in order to enhance the effectiveness of the thrust vectoring and/or to employ an alternative means of vectoring well established in the art. As for using the nozzle with a jet engine aboard an aircraft, this is taught by the Miller paper. It would have been obvious to one of ordinary skill in the art to employ the nozzle with a jet aircraft, as a well known application of such a nozzle."

Applicants respectfully submit that McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claims 31, 44, 51, and 63 that the

injected flow skews the sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30). Thus it is improper to apply the teachings of McCullough to the instance where shock waves are not created as is the case in the present invention.

The Applicants respectfully teach that Ernest teaches away from the subject matter of the present invention in that Ernest teaches thrust vectoring through the use of liquid vaporizations (Ernest; col. 2, lines 35-40). The present invention does not inject a liquid which then undergoes a phase change (vaporization) into the primary fluid flow. Additionally, the Applicants respectfully submit that Ernest vectors the primary flow through the Coanda effect. Ernest can be distinguished from the present invention as Ernest teaches that the primary flow may be vectored by a wall attachment effect. Ernest describes that a single liquid injection will cause the primary flow to lock on and remain locked on to the nozzle wall in the absence of another liquid injection (Ernest; col. 2, lines 5-13). Additionally, Ernest does not teach that the effective sonic plane and throat of the nozzle are skewed by the injection of liquid into the primary flow.

The Applicants submit that the present invention as recited in the claims does not use the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, effective location, and effective orientation of the nozzle throat or sonic plane, no matter the physical configuration of the nozzle or duct containing the primary flow.

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough, Ernst, or Miller to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

<u>REJECTIONS UNDER 35 USC § 103 OVER MCCULLOUGH IN VIEW OF EITHER ERNST MILLER ET AL. AND FURTHER IN VIEW OF EITHER KRANZ ET AL. OR WARREN.</u>

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Claims 51-69 stand rejected under 35 USC 103(a) as being unpatentable over McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS, as applied above, and further in view of either Kranz et al. (4,351,479) or Warren (3,204,405).

The Examiner states: "McCullough teaches various aspects of Applicant's claimed invention but does not teach the flow is pulsed. Kranz et al. teach a jet engine nozzle 7 having a plurality of injectors (a-f) spaced about the housing, and valve controllers 36 associated with the injectors, the controller directing the injectors to provide an unsteady, i.e., pulsed, fluidic cross flow. The pulsed cross flow is injected to control the effective flow area, throttle and also vector the primary fluidic flow (see especially col. 5, lines 9 and following). The pulsed cross flow partially blocks the opening of the nozzle and can be either symmetric (area control) or asymmetric (thrust vectoring) as desired. Please note that as the effective flow area for the primary fluid flow is controlled, the temperature and pressure of the primary gas is inherently controlled by variation of the primary fluid flow velocity. The pulsed cross flow controller inherently controls the frequency, amplitude and wave form of the pulses. Kranz et al. teach that by employ pulsed flow, more effective deflection of the incoming flow is achieved (col. 1, lines 7 and following). Warren et al. teach a thrust vectoring system for a reaction engine where pulsed flow (col. 9, lines 2 and following, especially circa line 63) is injected at the throat (e.g. Fig. 6a, 11, 121) to provide vectoring of the primary fluid. Warrant also teach that the pulsed fluid can be fuel. It would have been obvious to one of ordinary skill in the art to employ pulsed flow of the cross flow injected by McCullough, as taught by either Kranz et al. or Warren et al., to more effective control the cross flow penetration of McCullough, and to enhance the thrust vectoring ability."

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims

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that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Applicants respectfully teach that Ernest teaches away from the subject matter of the present invention in that Ernest teaches thrust vectoring through the use of liquid vaporizations (Ernest; col. 2, lines 35-40). The present invention does not inject a liquid which then undergoes a phase change (vaporization) into the primary fluid flow. Additionally, the Applicants respectfully submit that Ernest vectors the primary flow through the Coanda effect. Ernest can be distinguished from the present invention as Ernest teaches that the primary flow may be vectored by a wall attachment effect. Ernest describes that a single liquid injection will cause the primary flow to lock on and remain locked on to the nozzle wall in the absence of another liquid injection (Ernest; col. 2, lines 5-13). Additionally, Ernest does not teach that the effective sonic plane and throat of the nozzle are skewed by the injection of liquid into the primary flow.

The Applicants submit that the present invention as recited in the claims does not use the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, effective location, and effective orientation of the nozzle throat or sonic plane, no matter the physical configuration of the nozzle or duct containing the primary flow.

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). The Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

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One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, the Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

The Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, the Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

The Applicants submit that the present invention as recited in independent Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by

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varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat (see Claims 31, 44, 51, and 63). This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

The Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

The Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 09/621,795; page 20, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention in Claims 31, 44, 51, and 63.

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough, Ernst, Miller et al., Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

REJECTIONS UNDER 35 USC § 103 OVER MILLER ET AL. IN VIEW OF MCCULLOUGH.

Claims 51-54, 56, 57, 69-65, and 63-39, stand rejected under 35 USC 103(a) as being unpatentable over the AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642). The Examiner states: "Miller et al. teach a fixed geometry exhaust nozzle used for gas turbine/turbofan engines (which inherently employ compressors) where the nozzle area is varied by a cross flow injected in the upstream direction (Figs. 2-5) in order to achieve a variable throat area. At the throat, the primary flow reaches the sonic condition. Miller et al. show on the cover sheet of the paper that the flows from the primary and secondary injectors can be angled to oppose the flow. Miller et al. do not teach thrust vectoring. However, it is clear that in a fixed nozzle, thrust vectoring capacities are generally required in order to steer the nozzle, especially in a military aircraft. Miller et al. further teach very low injection angles are possible (see top left of Fig. 9) and hence, as the angles are very low, the angles will also be approximately parallel the vector angle, which would also be low. McCullough teaches a nozzle having a primary flow, a primary injector 16, and a secondary injector 18, and valve controllers 22 to direct a flow to vary the effective throat area of the nozzle and perform thrust vectoring (top of col. 2). McCullough further teaches the use of fuel (col. 2, lines 26-28). Alternately, for the controllers, it is clear that the valves require a controller to actuate them. It would have been obvious to one of ordinary skill in the art to employ a software based controller in addition to the valves, in order to provide the necessary control over the thrust vectoring and/or throat control. It would have been obvious to one of ordinary skill in the art to both control the throat area and thrust vector the nozzle of Miller et al., as taught by McCullough, in order to add vectoring capabilities to the nozzle of Miller et al."

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Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough and Miller to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

REJECTIONS UNDER 35 USC § 103 OVER MILLER ET AL. IN VIEW OF MCCULLOUGH, AND FURTHER IN VIEW OF EITHER KRANZ ET AL. OR WARREN.

Claims 51-69 stand rejected under 35 USC 103(a) as being unpatentable over the AIAA paper of Miller et al. (IAA 95-2603) of the IDS in view of McCullough (3,698,642), as applied above and further in view of either Kranz et al. (4,351,479) or Warran (3,204,405).

The Examiner states: "Miller et al. teach various aspects of Applicant's claimed invention but does not teach pulsing the flows nor the flows being fuel. Kranz et al. teach a jet engine nozzle 7 having a plurality of injectors (a-f) spaced about the housing, and valve controllers 36 associated with the injectors, the controller directing the injectors to provide an unsteady, i.e. pulsed, fluidic cross flow. The pulsed cross flow is injected to control the effective flow area, throttle and also vector the primary fluidic flow (see especially col. 5, lines 9 and following). The pulsed cross flow partially blocks the opening of the nozzle and

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can be either symmetric (area control) or asymmetric (thrust vectoring) as desired. Please note that as the effective flow area for the primary fluid flow is controlled, the temperature and pressure of the primary gas is inherently controlled by variation of the primary fluid flow velocity. The pulsed cross flow controller inherently controls the frequency, amplitude and wave form of the pulses. Kranz et al. teach that by employ pulsed flow, more effective deflection of the incoming flow is achieved (col. 1, lines 7 and following). Warren et al. teach a thrust vectoring system for a reaction engine where pulsed flow (col. 9, lines 2 and following, especially circa line 63) is injected at the throat (e.g. Fig. 6a, 11, 121) to provide vectoring of the primary fluid. Warrant also teach that the pulsed fluid can be fuel. It would have been obvious to one of ordinary skill in the art to employ pulsed flow of the cross flow injected by Miller et al., as taught by either Kranz et al. or Warren et al., to more effective control the cross flow penetration, and to enhance the thrust vectoring ability.

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). The Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the

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pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, the Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

The Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, the Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to

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follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

The Applicants submit that the present invention as recited in independent Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat. This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

The Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

The Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 08/906,731; page 16, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream

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disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention.

Therefore, the Applicants respectfully submit that one would not combine the teachings of Miller, McCullough, Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

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REJECTIONS UNDER 35 USC § 103 OVER MILLER ET AL. AND MCCULLOUGH IN VIEW OF EITHER ERNST; OR MILLER ET AL. IN VIEW OF MCCULLOUGH IN VIEW OF EITHER TERRIER OR JUSTICE.

Claims 31-35, 37-39, 40-42, 44-46, and 48 stand rejected under 35 USC 103(a) as being unpatentable over Miller et al. and McCullough, and further in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) or AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642), as applied above, and further in view of either Terrier (5,665,415) or Justice (6,000,635).

The Examiner states: "The above prior art teach various aspects of applicant's claimed invention but do not specifically teach a 3-D fixed nozzle. Terrier teaches (fig. 8) that ultra high aspect ratio biconvex aperture nozzles are old and well known in the fixed nozzle art. Justice teaches that it is old and well known in the fixed nozzle art employ an ultra high aspect ratio trapezoid aperture nozzle 33B (col. 2, circa line 63). It would have been obvious to one of ordinary skill in the art employ a 3-D nozzle, including either an ultra high aspect ratio biconvex or trapezoid aperture nozzle, as well known types of fixed nozzles utilized in the art.

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). The Applicants respectfully submit that Kranz et al. also teaches the

use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, the Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

The Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, the Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the

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control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

The Applicants submit that the present invention as recited in independent Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat. This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

The Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

The Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 08/906,731; page 16, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention.

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough, Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

REJECTIONS UNDER 35 USC § 103 OVER EITHER MCCULLOUGH IN VIEW OF EITHER ERNST OR MILLER ET AL. AND FURTHER IN VIEW OF EITHER KRANZ ET AL. OR WARREN; OR MILLER ET AL. IN VIEW OF MCCULLOUGH AND EITHER KRANZ ET AL. OR WARREN, AND FURTHER IN VIEW OF EITHER TERRIER OR JUSTICE.

Claims 31-50 are rejected under 35 USC 103(a) as being unpatentable over either McCullough (3,698,642) in view of either Ernst (3,294,323) or the AIAA paper of Miller et al. (AIAA 95-2603) and further in view of either Kranz et al. (4,351,479) or Warren (3,204,405) or AIAA paper of Miller et al. (AIAA 95-2603) of the IDS in view of McCullough (3,698,642) and either Kranz et al. (4,351,479) or Warren (3,204,405), as applied above, and further in view of either Terrier (5,665,415) or Justice (6,000,635). The above prior art teach various aspects of applicant's claimed invention but do not specifically teach a 3-D fixed nozzle. Terrier teaches (fig. 8) that ultra high aspect ratio biconvex aperture nozzles are old and well known in the fixed nozzle art. Justice teaches that it is old and well known in the fixed nozzle art employ an ultra high aspect ratio trapezoid aperture nozzle 33B (col. 2, circa line 63). It would have been obvious to one of ordinary skill in the art employ a 3-D nozzle, including either an ultra high aspect ratio biconvex or trapezoid aperture nozzle, as well as known types of fixed nozzles utilized in the art.

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Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims in Claim 75 that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Applicants respectfully teach that Ernest teaches away from the subject matter of the present invention in that Ernest teaches thrust vectoring through the use of liquid vaporizations (Ernest; col. 2, lines 35-40). The present invention does not inject a liquid which then undergoes a phase change (vaporization) into the primary fluid flow. Additionally, the Applicants respectfully submit that Ernest vectors the primary flow through the Coanda effect. Ernest can be distinguished from the present invention as Ernest teaches that the primary flow may be vectored by a wall attachment effect. Ernest describes that a single liquid injection will cause the primary flow to lock on and remain locked on to the nozzle wall in the absence of another liquid injection (Ernest; col. 2, lines 5-13). Additionally, Ernest does not teach that the effective sonic plane and throat of the nozzle are skewed by the injection of liquid into the primary flow.

The Applicants submit that the present invention as recited in the claims does not use the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, effective location, and effective orientation of the nozzle throat or sonic plane, no matter the physical configuration of the nozzle or duct containing the primary flow.

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5,

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lines 9 and following). The Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, the Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

The Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, the Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall

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attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

The Applicants submit that the present invention as recited in Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat. This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

The Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

The Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a

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# PGS.:	66		

COMMENTS:

In re Application of:	Daniel N. Miller *et al.*
Serial No.:	09/621,795
Filing Date:	July 21, 2000
Examiner:	Tae Jun Kim
Group Art Unit:	3746
Title:	METHOD AND APPARATUS OF ASYMMETRIC INJECTION INTO SUBSONIC FLOW OF A HIGH ASPECT RATIO/COMPLEX GEOMETRY NOZZLE

Per our telephone conversation on Thursday, please find attached the Appeal Brief filed on November 29, 2002. If you have any questions, please contact me at (512) 228-3611.

Part ~~#~~ 2

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predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 08/906,731; page 16, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention.

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough, Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

Requirements for a Prima Facie *Case of Obviousness*

In order to establish a *prima facie* case of obviousness, Section 2143 of the MPEP requires that:

> ...three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.

Motivation to Combine

Addressing the first criteria, the MPEP prescribes in Section 706.02(j) that

> The initial burden is on the examiner to provide some suggestion of the desirability of doing what the inventor has done. "To support the conclusion that the claimed invention is directed to obvious subject matter, either the references must expressly or impliedly suggest the claimed invention or the examiner must present a convincing line of reasoning as to why the artisan would have found the claimed invention to have been obvious in light of the teachings of the references." Ex parte Clapp, 227 USPQ 972, 973 (Bd. Pat. App. & Inter. 1985). See MPEP § 2144 - § 2144.09 for examples of reasoning supporting obviousness rejections.

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In the Final Action, the Examiner has not pointed out any teaching in the cited references that "expressly or impliedly suggest[s] the claimed invention." Nor has the Examiner "present[ed] a convincing line of reasoning as to why the artisan would have found the claimed invention to have been obvious in light of the teachings of the references." McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves, which form a gaseous, nonstructural throat. The present invention, in contrast, teaches that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks, which significantly impact the nozzle's thrust efficiency. The present invention claims that the injected flow skews the sonic plane towards the injector port (supplemental injectors) without producing a shock wave. Furthermore, Waren and Kranz teach the use of the Coanda effect, by shock vector control, to redirect a primary exhaust from the nozzle. As the present invention does to use shock vector control or the Coanda effect, it is improper to apply these teachings to the present invention. Thus, the Examiner's rejection fails to meet the first criteria for a *prima facie* case of obviousness.

Reasonable Expectation of Success

The hypothetical combiner, having combined McCullough and Miller et al. would find it impossible to avoid the creation of shock waves as taught in the present invention when creating the shock waves of McCullough. Thus, the hypothetical combiner of McCullough and Miller et al. would find it impossible, at times, to use the combined technologies in the way claimed for the invention of the present application. Furthermore, Waren and Kranz teach the use of the Coanda effect, by shock vector control, to redirect a primary exhaust from the nozzle. As the present invention does to use shock vector control or the Coanda effect, the hypothetical combiner could not vector a nozzles primary flow by skewing the effective throat of that nozzle. Instead, the hypothetical combiner would use shock vector control and not skew the effective throat of the nozzle in size or orientation as taught by the present invention. As a result, the Examiner's rejection fails to meet the second criteria for a *prima facie* case of obviousness.

Teaching or Suggestion of All Claim Limitations

The present application teaches, and all the claims of the present application claim, a A system for vectoring a primary flow by varying an effective throat or sonic plane within a ducted primary flow. As detailed above when rebutting rejections under 35 USC § 103 over either Mccullough in view of either Ernst or Miller et al. and further in view of either Kranz

et al. or Warren; or Miller et al. in view of Mccullough and either Kranz et al. or Warren, and further in view of either Terrier or Justice. These references fail to teach that the primary flow is vectored by skewing the effective throat.

Thus, the proposed combination of references neither teaches nor suggests all the claim limitations and, as such, the Examiner's rejection fails to meet the third criteria for a *prima facie* case of obviousness.

Withdrawal of Final Rejection

The Applicants respectfully submit that the Rejection within the Office Action dated May 31, 2002 is premature. The Applicants submit that the claims as originally submitted and now amended provide a system and method for vectoring a primary flow within a nozzle by skewing the effective throat or sonic plane of the nozzle. This is not taught in the cited prior art. The claimed invention as taught and claimed is improperly rejected by the cited prior art.

Applicants respectfully submit that the invention of McCullough teaches away from that of the present invention. McCullough specifically teaches that the flow of fluid through the injection ports creates shock waves which form a gaseous, nonstructural throat (McCullough: column 2, lines 4-8). The method of the present invention, in contrast to McCullough, claims that the fluidic injection of secondary flow into the subsonic portion of the flow field prevents the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page 40, lines 15-19). Furthermore, McCullough teaches that the nonstructural throat will be concentric about the longitudinal axis of the nozzle (McCullough: column 2, lines 9-11), while the present invention claims that the asymmetric cross flow from the injectors skews sonic plane towards the injector port (supplemental injectors) without producing a shock wave (U.S. Patent Application 09/621,795; page 43, lines 7-30).

The Applicants respectfully teach that Ernest teaches away from the subject matter of the present invention in that Ernest teaches thrust vectoring through the use of liquid vaporizations (Ernest; col. 2, lines 35-40). The present invention does not inject a liquid which then undergoes a phase change (vaporization) into the primary fluid flow. Additionally, the Applicants respectfully submit that Ernest vectors the primary flow through the Coanda effect. Ernest can be distinguished from the present invention as Ernest teaches

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that the primary flow may be vectored by a wall attachment effect. Ernest describes that a single liquid injection will cause the primary flow to lock on and remain locked on to the nozzle wall in the absence of another liquid injection (Ernest; col. 2, lines 5-13). Additionally, Ernest does not teach that the effective sonic plane and throat of the nozzle are skewed by the injection of liquid into the primary flow.

The Applicants submit that the present invention as recited in the claims does not use the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, effective location, and effective orientation of the nozzle throat or sonic plane, no matter the physical configuration of the nozzle or duct containing the primary flow.

The Examiner states that Kranz teaches a nozzle having a plurality of injectors based about a nozzle to provide an unsteady fluidic flow. The pulsed cross flow is injected to control the effective flow area, throttle and vector the primary fluidic flow (Kranz: column 5, lines 9 and following). The Applicants respectfully submit that Kranz et al. also teaches the use of the Coanda effect with fluidic jet deflection by control pulses which shift the primary flow from one wall of the nozzle to another wall of the nozzle (Kranz: column 1, lines 24-30). Furthermore, Kranz et al. states that a control pulse is only necessary for the duration of the switching process. As soon as the thrust jet (primary flow) is deflected into one of the pockets shown in 16-20 (shown in Kranz Figure 1), the primary flow remains automatically and without any further control pulse under the action of the Coanda effect (Kranz: column 1, lines 9-28).

One skilled in the art would not apply the teachings of Kranz et al. to the present invention in that Kranz teaches according to the historical approach of shock vector control. This is applicable where a nozzle has an expansion area ratio typically between 3 to 10. Such a nozzle is widened beyond the expansion ratio corresponding to the ambient pressure (Kranz: column 1, lines 17-19). Throat skewing as claimed by the present invention cannot be applied to an over-expanded nozzle. Furthermore, the Applicants respectfully submit that shock vector control also cannot be applied to the small area expansion ratio nozzle as taught and claimed by the present invention. The present invention injects the secondary flow into the subsonic portion of the flow field preventing the formation of shocks which can significantly impact the nozzle's thrust efficiency (U.S. Patent Application 09/621,795; page

40, lines 15-17). The Applicants respectfully submit that the prior art does not teach the skewing of the throat or sonic plane of a nozzle as taught and claimed by the present invention. Additionally, the nozzle's thrust efficiency is greatly increased in the present invention. One might encounter an efficiency of 0.9 when using shock vector control, while one would encounter 0.95 with the small area expansion ratio nozzle claimed by the present invention.

The Applicants respectfully submit that Warren teaches away from the subject matter of the present invention in that Warren teaches a thrust-vectoring system for a reaction jet nozzle wherein a pulse flow is injected at the throat in order to vector the primary fluid. The pulsed fluid is of short duration and thus continuous control fluid streams are not required to maintain a proper deflection of the propelling jet. (Warren: column 9, lines 63-67). Additionally, the Applicants respectfully submit that Warren vectors the primary flow through the Coanda effect. Warren can be distinguished from the present invention as Warren teaches that the primary flow may be vectored by the Coanda effect (a wall attachment effect). Warren describes that a single fluid pulse or jet issuing from one of the control nozzles will cause the propelling jet (primary flow) to lock on and remain locked on to the nozzle wall in the absence of another fluid pulse from another control nozzle. (Warren: column 9, lines 59-63.) Coanda observed that a stream of fluid exiting a nozzle tends to follow a nearby curved or flat surface as long as the curvature of the surface with respect to the fluid flow is not too sharp.

The Applicants submit that the present invention as recited in Claims 31, 44, 51, and 63 do not utilize the Coanda effect. Rather, the primary flow is vectored by varying the effective throat of the nozzle. The present invention claims that the injection of pulsed cross flow from the primary and supplemental injectors can manipulate the effective area, location, and orientation of the nozzle throat. This allows a user to not merely manipulate the direction of the primary flow through in a discrete fashion as taught in the prior art with the use of the Coanda effect. Rather, one can continuously vector the primary flow and area, location, and orientation of the nozzle throat.

The Applicants respectfully submit that the Coanda effect merely allows the creation of a binary device where the thrust may be vectored either in a first or second direction. The present invention in comparison claims a smooth and continuous control system for vectoring

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the exhaust thrust by manipulating the size, location, and orientation of the sonic plane within the nozzle throat.

Applicants respectfully submit that in an alternate embodiment, Warren still only teaches the Coanda effect to provide a tri-stable flow patter. Warren states that in this embodiment, that control fluid, supplied through one wall to the separated boundary layer, causes deflection of the propelling jet away from the control fluid input. The propelling jet thereupon clings to the opposite wall until the control signal is discontinued, at which time it returns to a center flow position (Warren: column 9, line 72; column 10, line 4).

The Applicants respectfully submit that the present invention does not provide a pulsed control signal to serve as a binary switch for vectoring the primary flow of a nozzle, rather the present invention claims a pulsed cross flow that provides a smooth, continuous control signal with which to vector the primary flow of the nozzle by controlling the size, location, and orientation of the sonic plane (or throat) of the nozzle in the present invention. This is taught in the present invention as the pulsed fluidic cross flow that has a predetermined frequency, amplitude or wave injector that is controlled by a controller associated with the injector (U.S. patent Application 08/906,731; page 16, lines 1-25).

The present invention is distinguishable from the prior art of Warren, which utilizes the Coanda effect. A fluidic amplifier device such as those taught in Warren is not robust against errors in the control function as the Coanda effect is unstable as downstream disturbances may propagate upstream in the exhaust flow to redirect the primary flow from one wall of the divergent portion of the nozzle to another. This type of thrust vector control is inadequate for uses such as aircraft control, as claimed by the present invention.

Therefore, the Applicants respectfully submit that one would not apply the teachings of McCullough, Kranz et al., or Warren to the present invention as this prior art teaches manipulating the primary flow vector in the divergent section of a high-expansion area ratio nozzle merely by controlling the primary flow vector through the Coanda effect. The present invention claims the combined thrust and vector control by skewing the sonic plane or throat of a small expansion area ratio nozzle.

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Summary/Conclusion

In summary, the rejection of Claims 31-33, 35-42, 44, 46-49, 51-57, 59-63, and 65-68 under 35 U.S.C. 103(a) meets none of the three requirements for a *prima facie* case of obviousness: there has been no showing of a motivation to combine outside the Applicant's own application; the proposed combination would be unusable, at times, for the function claimed for the invention of the present application; and the proposed combination of references neither teaches nor suggests all the claim limitations.

(9) Appendix

A listing of the pending claims, as amended in the Amendment filed along with this Brief, is set forth in the attached Appendix.

Conclusion

For the reasons set forth above, Appellant requests that the rejection be reversed and that Claims 31-33, 35-42, 44, 46-49, 51-57, 59-63, and 65-68 be allowed so that this case may pass to issue.

Respectfully submitted,

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Appendix

The claims involved in this appeal are set forth below:

31. (Amended) A system for vectoring a primary flow by varying an effective throat or sonic plane within a ducted primary flow, comprising:

an opening for accepting the primary flow;

at least one primary injector located wherein said at least one injector is inclined to oppose the primary flow up-stream of said effective throat or sonic plane;

at least one supplemental injector wherein said at least one supplemental injector is located downstream of the at least one primary injector, wherein said at least one supplemental injector is inclined to oppose the primary flow, and wherein the at least one primary and supplemental injectors provide a flow field opposed to a subsonic portion of the primary flow in order to vector the primary flow; and

at least one controller operable to direct said at least one primary and supplemental injector to provide a flow operable to vary the effective throat or sonic plane.

32. (Amended) The system for vectoring a primary flow of Claim 31, further comprising:

a physical throat, within a duct, wherein the physical throat comprises a region of lowest cross-sectional area, in the primary flow.

33. (Amended) The system for vectoring a primary flow of Claim 32 wherein a plurality of primary injectors is located proximate to said physical throat.

34. Cancelled.

35. (Amended) The system for vectoring a primary flow of Claim 31 wherein injectors inject fluid asymmetrically, to redirect the primary flow along an intended vectoring plane.

36. (Amended) The system for vectoring a primary flow of Claim 35 wherein a plurality of primary and secondary injectors inject fluidic pulses.

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37. (Amended) The system for vectoring a primary flow of Claim 33, wherein a plurality of secondary injectors are arranged to inject fluid to oppose the primary flow and in parallel to the intended vectoring plane.

38. (Amended) The system for vectoring a primary flow of Claim 37 wherein the plurality of primary injectors and the plurality of secondary injectors inject fluid symmetrically, resulting in a change in a discharge coefficient in the nozzle.

39. Cancelled.

40. (Amended) The system for vectoring a primary flow of Claim 31 wherein injected fluid comprises compressed gas.

41. (Amended) The system for vectoring a primary flow of Claim 31 wherein injected fluid comprises fuel.

42. (Amended) The system for vectoring a primary flow of Claim 31, further comprising:

at least one controller, operable to direct said at least one primary injector and/or said at least one supplemental injector.

43. Cancelled.

44. (Amended) A method for vectoring a primary flow of fluid in a 3-D nozzle, comprising the steps of:

injecting fluid from a plurality of primary injectors opposed to a primary flow of the fluid and approximately parallel to an intended vectoring plane, the plurality of injectors located proximate to a throat;

injecting fluid from a plurality of supplemental injectors opposed to the primary flow wherein said second plurality of supplemental injectors are located downstream of the throat, and wherein the fluid injected by said primary and/or supplemental injectors varies or skews an effective throat or sonic plane of said 3-D nozzle.

45. Cancelled.

46. (Amended) The method of Claim 44, further comprising:

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expelling from a second plurality of injectors the injection fluid in a direction inclined to oppose the primary flow of the fluid and approximately parallel to an intended vectoring plane, wherein said supplemental plurality of injectors are located proximate to the throat.

47. (Amended) The method of Claim 44 wherein fluid is injected by said primary and/or supplemental injectors in fluidic pulses.

48. (Amended) The method of Claim 44 wherein the injected fluid comprises a compressed gas.

49. (Amended) The method of Claim 44 wherein the injected fluid comprises fuel.

50. Cancelled.

51. (Amended) A system for vectoring a primary flow comprising:

a nozzle having an inner surface and a throat, wherein the throat comprises a region within the nozzle of lowest cross-sectional area, the throat being situated in a path of the primary flow of fluid;

a plurality of primary injectors arranged along the inner surface of the nozzle, the plurality of injectors arranged to oppose the primary flow of fluid in a first intended vectoring plane, and wherein said primary injectors skew an effective throat or sonic plane within said nozzle; and

at least one controller operable to direct said at least one primary and supplemental injector to provide a flow operable to vary the effective throat or sonic plane.

52. (Amended) The system for vectoring a primary flow of Claim 51 wherein the plurality of injectors is located proximate to the throat.

53. (Amended) The system for vectoring a primary flow of Claim 52, further comprising:

a plurality of supplemental injectors located downstream of the throat and arranged along the inner surface of the nozzle, to oppose the primary flow in a second intended vectoring plane.

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54. (Amended) The system for vectoring a primary flow of Claim 53 wherein the plurality of primary and supplemental injectors inject fluid asymmetrically, resulting in a change in a thrust vector associated with the primary flow of the fluid, the change in the thrust vector lying within the first and/or second intended vectoring plane.

55. (Amended) The system for vectoring a primary flow of Claim 54 wherein the plurality of primary and supplemental injectors inject fluidic pulses.

56. (Amended) The system for vectoring a primary flow of Claim 53, wherein said supplemental injectors are:

located proximate to the throat.

57. (Amended) The system for vectoring a primary flow of Claim 56 wherein the plurality of primary and/or supplemental injectors inject fluid symmetrically, resulting in a change in a discharge coefficient for the nozzle.

58. Cancelled.

59. (Amended) The system for vectoring a primary flow of Claim 51 wherein the injected fluid comprises compressed gas.

60. (Amended) The system for vectoring a primary flow of Claim 51 wherein the injected fluid comprises fuel.

61. (Amended) The system for vectoring a primary flow of Claim 53, further comprising:

at least one controller, operable to direct said primary and/or supplemental injectors.

62. (Amended) The system for vectoring a primary flow of Claim 61, wherein said at least one controller, directs said primary and/or supplemental injectors to inject fluidic pulses.

63. (Amended) A method for vectoring a primary flow within a nozzle comprising the steps of:

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injecting from a plurality of primary injectors a fluid opposed to the primary flow wherein said plurality of primary injectors are located proximate to a throat of the nozzle;

injecting from a plurality of supplemental injectors fluid to oppose the primary flow, the plurality of supplemental injectors located downstream of the throat, wherein said injected fluid skews or varies an effective throat or sonic plane within the nozzle.

64. Cancelled.

65. (Amended) The method of Claim 63, wherein said supplemental injectors are located proximate to the throat.

66. (Amended) The method of Claim 63 wherein fluid is injected as fluidic pulses.

67. (Amended) The method of Claim 63 wherein the injected fluid comprises compressed gas.

68. (Amended) The method of Claim 63 wherein the injected fluid comprises fuel.

69. Cancelled.

70. Cancelled.

71. Cancelled.

72. Cancelled.

73. Cancelled.

74. Cancelled.

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